

AMENDMENT TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

LISTING OF CLAIMS

1 – 120 (cancelled)

121. (new) In a geometric pattern matching apparatus for refining a starting pose of an object in a run-time image, the object having an expected shape and a true pose in the run-time image, the starting pose representing an initial estimate of the true pose of the object in the run-time image, the geometric pattern matching apparatus having (1) a stored model pattern, the stored model pattern including a geometric description of the expected shape of the object, the geometric description including a plurality of pattern boundary points, and a field of force vectors, the field being a vector-valued function of position that relates force vectors to pattern boundary points, (2) a feature detector adapted to detect in the run-time image a plurality of image boundary points, and (3) a sequential pose refinement module having an evaluate module, the evaluate module comprising:

a field strength evaluator adapted to receive a force magnitude component of a force vector corresponding to an image boundary point, and an error signal, and adapted to provide a confidence factor.

122. (new) The evaluate module of claim 121, further including:

a weight selector adapted to receive the confidence factor and a first control code, and adapted to provide a weight value if the first control code indicates that the image boundary point is to be used for pose refinement, and to provide a zero value if the first control code indicates that the image boundary point is not to be used for pose refinement.

123. (new) The evaluate module of claim 121, further including:

an eval selector adapted to receive the confidence factor and a first control code, and adapted to provide an eval value if the first control code indicates that the image boundary point corresponds to a portion of the stored model pattern, and to provide a zero value if the first control code indicates that the image boundary point does not correspond to any portion of the stored model pattern.

124. (new) The evaluate module of claim 121, wherein the confidence factor falls within the range 0 to 1.

125. (new) The evaluate module of claim 121, further including:

a field direction evaluator adapted to receive a force direction component of a force vector and a direction (field), and to provide a force direction confidence factor; and

- a combiner adapted to combine at least the field strength confidence factor, and the force direction confidence factor, so as to provide an overall confidence score.
126. (new) The evaluate module of claim 125, further including a magnitude evaluator adapted to receive the gradient magnitude of an image boundary point, and to provide a magnitude confidence factor.
127. (new) The evaluate module of claim 126, wherein the magnitude evaluator includes:
- a magnitude threshold; and
 - a greater-than module that provides the magnitude confidence factor.
128. (new) The evaluate module of claim 127, wherein the magnitude threshold is a fuzzy threshold, and the greater-than module is a fuzzy greater-than module.
129. (new) The evaluate module of claim 125, wherein the field direction evaluator includes:
- a subtractor adapted to receive an image boundary point direction and a pattern boundary gradient direction based on at least some of the plurality of pattern boundary points, and for providing a direction comparison angle;
 - an angle limiter adapted to receive the direction comparison angle and a second control code, and for providing the direction comparison angle unmodified if the second control code indicates that gradient polarity is to be considered, and limits the direction comparison angle if the second control code indicates that gradient polarity is not to be considered;
 - an absolute value module adapted to receive the direction comparison angle, and to provide a magnitude of the direction comparison angle;
 - a threshold selector adapted to receive a third control code, and to provide a field direction threshold if the third control code indicates “no corner”, else to provide a field corner threshold; and
 - a less-than module adapted to receive both the threshold from the threshold selector and the absolute value, and for providing the force direction confidence factor.
130. (new) The evaluate module of claim 129, wherein the less-than module is a fuzzy less-than module, and the field direction threshold and the field corner threshold are both fuzzy thresholds.
131. (new) The evaluate module of claim 125, wherein the field strength evaluator includes:
- an absolute value module adapted to receive a force magnitude component of a force vector corresponding to an image boundary point, and for providing a length of the force magnitude component;
 - a less-than module adapted to receive both the length of the force magnitude component and a field strength threshold, and for providing the force direction confidence factor.

132. (new) The evaluate module of claim 131, wherein the less-than module is a fuzzy less-than module, and the field strength threshold is a fuzzy threshold.
133. (new) The evaluate module of claim 131, wherein the field strength threshold is provided by an adder that receives an error signal, and adds the error signal to a field strength margin.
134. (new) The evaluate module of claim 133, wherein the error signal is from a previous pose refinement step, and the field strength threshold changes after each pose refinement step.
135. (new) The evaluate module of claim 121, further including:
- a field direction evaluator adapted to receive a force direction component of a force vector and a direction (field), and to provide a force direction confidence factor;
 - a fuzzy not element adapted to receive the force direction confidence factor and provide an inverted force direction confidence factor;
 - a magnitude evaluator adapted to receive the gradient magnitude of an image boundary point, and to provide a magnitude confidence factor; and
 - a combiner adapted to combine the inverted force direction confidence factor and the magnitude confidence factor, so as to provide an overall clutter confidence score.
136. (new) The evaluate module of claim 135, further including:
- a clutter selector adapted to receive the overall clutter confidence score and a first control code, and adapted to provide a clutter value if the first control code does not indicate “don’t care”, and to provide a zero value otherwise.
137. (new) The evaluate module of claim 135, wherein the magnitude evaluator includes:
- a magnitude threshold; and
 - a greater-than module that receives the gradient magnitude of an image boundary point and the magnitude threshold, and provides the magnitude confidence factor.
138. (new) The evaluate module of claim 137, wherein the magnitude threshold is a fuzzy threshold, the magnitude threshold is a fuzzy magnitude threshold, and the greater-than module is a fuzzy greater-than module.
139. (new) The evaluate module of claim 121, further including:
- a field direction evaluator adapted to receive a force direction component of a force vector and a direction (field), and to provide a force direction confidence factor;
 - a ‘not’ element adapted to receive the force direction confidence factor and provide an inversion of the force direction confidence factor; and
 - a clutter selector adapted to receive the inversion of the force direction confidence factor and a first control code, and adapted to provide a

clutter value if the first control code does not indicate “don’t care”, and to provide a zero value otherwise.

140. (new) The evaluate module of claim 139, further including:

a magnitude evaluator adapted to receive the gradient magnitude of an image boundary point, and to provide a magnitude confidence factor; and

a combiner adapted to combine the inverted force direction confidence factor and the magnitude confidence factor, so as to provide an overall clutter confidence score to be received by the clutter selector.

141. (new) The evaluate module of claim 139, wherein the field direction evaluator includes:

a subtractor adapted to receive an image boundary point direction and a pattern boundary gradient direction based on at least some of the plurality of pattern boundary points, and for providing a direction comparison angle;

an angle limiter adapted to receive the direction comparison angle and a second control code, and for providing the direction comparison angle unmodified if the second control code indicates that gradient polarity is to be considered, and limits the direction comparison angle if the second control code indicates that gradient polarity is not to be considered;

an absolute value module adapted to receive the direction comparison angle, and to provide a magnitude of the direction comparison angle;

a threshold selector adapted to receive a third control code, and to provide a field direction threshold if the third control code indicates “no corner”, else to provide a field corner threshold; and

a less-than module adapted to receive both the threshold from the threshold selector and the absolute value, and for providing the force direction confidence factor.

142. (new) The evaluate module of claim 141, wherein the less-than module is a fuzzy less-than module, the ‘not’ element is a fuzzy ‘not’ element, and the field direction threshold and the field corner threshold are both fuzzy thresholds.

143. (new) The evaluate module of claim 140, wherein the magnitude evaluator includes:

a magnitude threshold; and

a greater-than module that receives the gradient magnitude of an image boundary point and the magnitude threshold, and provides the magnitude confidence factor.